

of an on line 30 Hz video photogrammetry system for real-time 3 dimensional control presented at the Symposium of Commission V Photogrammetry for Industry, Stockholm, August 1978, together with many of the references referred to therein gives many of the underlying equations of solution of photogrammetry particularly with a single camera. Another reference relating to use of two or more cameras, is Development of Stereo Vision for Industrial Inspection, Dr. S. F. El-Hakim, Proceedings of the Instrument Society of America (ISA) Symposium, Calgary Alta, Apr. 3-5, 1989. This paper too has several useful references to the photogrammetry art.

[0039] Generally speaking, while several prior art references have provided pieces of the puzzle, none has disclosed a workable system capable of widespread use, the variety and scope of embodiments herein, nor the breadth and novelty of applications made possible with electro-optical determination of object position and/or orientation.

[0040] In this invention, many embodiments may operate with natural features, colored targets, self-illuminated targets such as LEDS, or with retroreflective targets. Generally the latter two give the best results from the point of view of speed and reliability of detection—of major importance to widespread dissemination of the technology.

[0041] However, of these two, only the retroreflector is both low cost, and totally unobtrusive to the user. Despite certain problems using same, it is the preferred type of target for general use, at least for detection in more than 3 degrees of freedom. Even in only two degrees, where standard “blob” type image processing might reasonably be used to find ones finger for example, (cf U.S. Pat. No. 5,168,531 by Sigel), use of simple glass bead based, or molded plastic corner cube based retroreflectors allows much higher frequency response (eg 30 Hz, 60 Hz, or even higher detection rates) from the multiple incidence angles needed in normal environments, also with lower cost computers under a wider variety of conditions—and is more reliable as well.(at least with todays PC processing power).

BRIEF SUMMARY OF THE INVENTION

[0042] Numerous 3D input apparatus exist today. As direct computer input for screen manipulation, the most common is the “Mouse” that is manipulated in x and y, and through various artifices in the computer program driving the display, provides some control in z-axis. In 3 dimensions (3-D) however, this is indirect, time consuming, artificial, and requires considerable training to do well. Similar comments relate to joysticks, which in their original function were designed for input of two angles.

[0043] In the computer game world as well; the mouse, joy stick and other 2D devices prevail today.

[0044] The disclosed invention is optically based, and generally uses unobtrusive specialized datum’s on, or incorporated within, an object whose 3D position and/or orientation is desired to be inputted to a computer. Typically such datums are viewed with a single tv camera, or two tv cameras forming a stereo pair. A preferred location for the camera(s) is proximate the computer display, looking outward therefrom, or to the top or side of the human work or play space.

[0045] While many aspects of the invention can be used without specialized datum’s (e.g. a retroreflective tape on

ones finger, versus use of the natural finger image itself), these specialized datum’s have been found to work more reliably, and at lowest cost using technology which can be capable of wide dissemination in the next few years. This is very important commercially. Even where only two-dimensional position is desired, such as x, y location of a finger tip, this is still the case.

[0046] For degrees of freedom beyond 3, we feel such specialized datum based technology is the only practical method today. Retroreflective glass bead tape, or beading, such as composed of Scotchlite 7615 by 3M co., provides a point, line, or other desirably shaped datum which can be easily attached to any object desired, and which has high brightness and contrast to surroundings such as parts of a human, clothes, a room etc, when illuminated with incident light along the optical axis of the viewing optics such as that of a TV camera. This in turn allows cameras to be used in normal environments, and having fast integration times capable of capturing common motions desired, and allows datums to be distinguished easily which greatly reduces computer processing time and cost.

[0047] Retroreflective or other datums are often distinguished by color or shape as well as brightness. Other target datums suitable can be distinguished just on color or shape or pattern, but do not have the brightness advantage offered by the retro. Suitable Retroreflectors can alternatively be glass, plastic or retroreflective glass bead paints, and can be other forms of retroreflectors than beads, such as corner cubes. But the beaded type is most useful. Shapes of datums found to be useful have been for example dots, rings, lines, edge outlines, triangles, and combinations of the foregoing,

[0048] It is a goal of this invention to provide a means for data entry that has the following key attributes among others:

[0049] Full 3D (up to 6 degrees of freedom, eg x, y, z, roll, pitch, yaw) real time dynamic input using artifacts, aliases, portions of the human body, or combinations thereof

[0050] Very low cost, due also to ability to share cost with other computer input functions such as document reading, picture telephony, etc.

[0051] Generic versatility—can be used for many purposes, and saves as well on learning new and different systems for those purposes.

[0052] Unobtrusive to the user

[0053] Fast response, suitable for high speed gaming as well as desk use.

[0054] Compatible as input to large screen displays—including wall projections

[0055] Unique ability to create physically real “Alias” or “surrogate” objects

[0056] Unique ability to provide realistic tactile feel of objects in hand or against other objects, without adding cost

[0057] A unique ability to enable “Physical” and “Natural” experience. It makes using computers fun, and allows the very young to participate. And it